

SOME POINTS IN THE EPIDEMIOLOGY OF AN OUTBREAK OF CEREBRO-SPINAL FEVER IN HONG KONG, 1918.

BY A. M. GALE, B.Sc., M.D. (GLASGOW).

Acting Medical Officer of Health, Hong Kong, 1918.

(With 3 Charts, 2 Maps and 1 Figure.)

TABLE OF CONTENTS.

	PAGE
I. Pre-epidemic Period	289
Outbreak in Manila	289
Evidence as to existence of sporadic cases of cerebro-spinal fever in Hong Kong	290
Pre-epidemic infectious diseases	290
II. Diagnosis—Onset and Course of Epidemic	291
Daily incidence of cases (with Chart No. 3)	291
Mortality	291
Missed cases	292
Age and sex incidence (with Charts Nos. 1 and 2)	293
Incidence among Europeans	295
III. Meteorological Conditions (with Chart No. 3)	297
Conclusions as to influence on the course of the epidemic	299
IV. Geographical Distribution and Overcrowding	299
Distribution of the population	299
Estimation of population of the city of Victoria	301
Density per acre	301
Migration of the population	302
Housing conditions in Hong Kong	303
Spot maps (Maps I and II)	306
V. Habits of the Chinese	308
VI. Influence of Length of Residence in the Colony on Case Incidence	309
VII. Occupation Incidence	310
VIII. Carrier Relation to the Epidemic	311
IX. Summary of Conclusions	316

I. PRE-EPIDEMIC PERIOD.

PREVIOUS to 9th February, 1918, the date on which it was first recognised that an epidemic of cerebro-spinal fever, or epidemic meningitis prevailed in Hong Kong, there existed no records of any former epidemic in Hong Kong, or on the China coast. In 1915, however, an epidemic of 70 known cases occurred in the Philippines, of which Manila is the next port of call to Hong Kong of the trans-Pacific steamships.

In November, 1917, a few weeks after taking up office as Medical Officer of Health, on compiling mortality statistics, I observed that in the previous six months, from May until October, 67 certificates of death from "meningitis" undefined were issued in the colony. Of these 67 cases, all of Chinese nationality, 46 were issued from one hospital out-patient department, and 38 of the death certificates were signed by one medical man, Dr X. I asked Dr X if he had any reason to suspect any of these cases to be sporadic cerebro-spinal fever, and he replied that he could not say, but that these Chinese cases were mostly children brought to him at the point of death with obvious signs of meningitis. He agreed to enquire more particularly into future cases and to take, when possible, specimens of cerebro-spinal fluid and submit them to the bacteriological department for diagnosis. One such sample was submitted for diagnosis without result.

In the mortality statistics for the year 1917, compiled by myself, there were reported 57 deaths from "tubercular meningitis," including one mortuary return, and 99 deaths from "meningitis" undefined, including three mortuary returns, a total of 156 deaths from some form of meningitis. In the sanitary reports of the years previous to this the number of deaths from tubercular meningitis was not stated, but for 1916 the number of deaths under the heading of nervous diseases labelled "meningitis" was 142, of which one only was a mortuary return: for 1915 the similar return was 17, including one mortuary case: for 1914 there were 93 cases, including three mortuary returns further differentiated as septic meningitis. These meningitis returns from 1914-1916 inclusive must be taken to be in addition to the returns of deaths from tubercular meningitis which, in the Hong Kong reports, were included under the heading of tubercular disease.

If posterior basic meningitis in young children¹ is accepted as identical with sporadic cases of cerebro-spinal fever, it is probable that these returns (varying from 93, 17, 142 to 99 in four successive years), with the further observation that three cases in 1914 were reported from the mortuary as septic meningitis, point to the conclusion that cerebro-spinal fever existed to some extent in the colony before 1918.

Pre-epidemic infectious disease. It was the subject of much comment during the months of December, 1917, and January, 1918, that a very widespread infection of influenza colds, or catarrhal pharyngitis, of varying severity existed in the colony. The weather during this period was ideal, clear, cold and constant brilliant sunshine, but owing to the lack of rain there was a good deal of dust flying about and it was the fashion to ascribe these attacks to dust irritation, or infection. At this time measles also existed in the colony, but to a quite unknown extent, as measles is not a notifiable disease in Hong Kong. From January 28th to February 5th eight cases of death from haemorrhagic smallpox were reported from the mortuary, and on February 5th and February 6th four additional cases were reported. As smallpox was

¹ *Cerebro-spinal Fever in Camps or Barracks*, by Sir W. Osler, M.D., F.R.S., 30. 1. 15.

non-existent in the colony at this time, the occurrence of 12 consecutive cases of haemorrhagic smallpox and no single case of ordinary smallpox gave rise to discussion and the suspicion that the diagnosis might be mistaken.

From the date of the recognition of the epidemic on February 9th no further cases of haemorrhagic, or ordinary, smallpox were reported for some months, and, as those responsible for the notification of these cases agreed that they were identical in appearance with many of the cases of cerebro-spinal fever brought in dead, it may be assumed that these were also cases of cerebro-spinal fever and that the epidemic had already existed in the colony for some time before it was recognised.

During the last two weeks in January it was reported from the Tung Wah hospital for Chinese that several cases had died in an acute typhoid condition, that the Widal reaction had been consistently negative, but that the death certificate was signed typhoid fever in lieu of a better diagnosis. In view of subsequent experience of the epidemic in which many of the verified cases presented an identical clinical picture with these other suspicious typhoid cases, it was considered that the former diagnosis of typhoid fever should be changed to that of cerebro-spinal fever.

II. DIAGNOSIS—ONSET AND COURSE OF EPIDEMIC.

On February 9th a telephone message was received that there were several cases in hospital suspected to be suffering from cerebro-spinal fever. Most of these cases had been for a few days in hospital but it was not until a typical case with meningeal symptoms was seen and the cerebro-spinal fluid drawn off that suspicion was cast on the others.

On February 11th eight verified cases were reported and from that date the epidemic steadily progressed.

The epidemic reached its height in March with an average of 14 cases reported per day, the highest number recorded for any one day being 24, on March 26th, out of which 18 were brought in dead or died the same day as discovered (see Chart No. 3, p. 296).

For the purposes of this paper the records from February 9th to June 1st are taken, at which date the epidemic was gradually tailing off, and includes a total of 1040 cases. The doubtful typhoid and haemorrhagic small pox cases are not included.

The following table is arranged to show for each month the average number of cases per day, the average number of cases brought in dead per day, the highest number recorded in any one day of new cases, and cases found dead or dying.

Table A.

	Feb.	March	April	May
Average No. cases per day	9	14	9	4
„ „ „ brought in dead ...	4.4	7	4.5	2.6
Highest No. cases recorded for one day ...	18	24	14	10
„ „ brought in dead for one day	6	18	9	6

Out of the 1040 known cases, 889 died, which gives a mortality of 85.48 per cent., but this includes those cases, 519 in all, brought in dead or *in extremis*.

It is interesting to note that the curve of the number of cases daily brought in dead, or *in extremis*, follows the curve of the daily incidence of cases (see Chart No. 3, p. 296).

This is of special interest when viewed in the light of Magelssen's observations in Copenhagen. He demonstrated by curves "that fluctuations in mortality cannot be ascribed to the merit of hygiene alone. They seem to be dependent on the temperature or some unknown factor closely associated with it, which controls the fluctuations in the mortality, the *constitutio epidemica*."

In Hong Kong, where the epidemic was practically uncontrolled, this fluctuation is very well marked and bears a definite relationship to the meteorological conditions, as is shown in Chart No. 3 (p. 296), discussed under the heading of meteorological conditions.

Missed cases. There is no doubt that this number, 1040, does not by any means represent the total number of cases which occurred. To this must be added:

1. Those cases which, on becoming sick, left the colony for their homes in the country.

This is a common practice in Hong Kong, where so many of the male population live in common lodging houses and keep their wives and children in Canton, or "Canton more far."

2. Those cases which were concealed ignorantly or deliberately by the Chinese practitioners.

As the Chinese are willing to pay large sums of money in order to avoid interference in their homes from sanitary officers, this might include a fairly large number of cases.

3. Mild cases which escaped detection. There is every reason to suppose that this included a very large number of cases.

(a) About this time many of the local doctors noticed that a large number of cases occurred in their practice, presenting features identical with mild cases of cerebro-spinal fever, *i.e.* headache, sickness, stiffness of neck, varying degrees of prostration and complaint of dazed sensation.

When the Chinese schools re-opened at the end of February, after the China New Year holidays, the headmistress of one of the girls' schools containing between 400-500 pupils, situated in a very crowded portion of the town, observed to me that several of the teachers had commented on the strange appearance of a number of the pupils. They looked ill and exhausted, but it was the peculiar dazed expression in the eyes that attracted attention. Upon enquiry they said they had been ill with fever, headache and vomiting. Further information was impossible to obtain as no doctor had attended, but it is probable that these may have been mild cases of this disease. This peculiar dazed expression in the eyes of Chinese convalescents was commented on by

several observers, and was particularly noticeable in contrast to the usual unfathomable fixed oriental stare.

(b) At the local British Medical Association meeting in March, called to discuss the epidemic, the Hon. Secretary, Dr Marriott, stated that he had about an average of ten cases a day presenting the following features in varying severity—headache, stiffness of neck, dazed sensation, slight fever and vomiting. These rendered the patient more or less prostrate, but in a few days recovery took place and there were no after effects. Several other members gave similar experiences, but as no routine examination of the cerebro-spinal fluid had been made and no naso-pharyngeal swab taken, no conclusion was reached as to the nature of the diagnosis.

(c) It is quite impossible to estimate the number of the mild and missed cases, but it is reasonable to assume that they form a not inconsiderable number, which, if added to the number of known cases would lessen the percentage mortality in this epidemic.

Age and sex incidence. Out of a total of 1040 cases, with a mortality of 85·48 per cent., 635, or 61 per cent., were found to be males, 541 of whom died, giving a male mortality of 85·19 per cent., and 405 females, 348 of whom died, giving a similar female mortality of 85·92 per cent.

Sophian points out that Dr Steiner, State Medical Officer for Texas, obtained somewhat similar figures in an epidemic of cerebro-spinal fever, where, out of 2,575 cases, the number of males affected was 1595, or 62 per cent.¹

For the purpose of this paper the cases have been arranged in age periods of five years.

It will be seen from Chart No. 1, p. 294, which is an analysis of 1040 cases to show age and sex incidence and mortality that the largest number of cases, viz. 318, or 30·5 per cent., of the total number of cases, occurred in children of five years and under, with the high mortality of 307, or 96·5 per cent. At this age period the male cases are slightly in excess of the female.

In the second age period, from six to ten years, the number of cases falls to 123, or 11·8 per cent. of the total number.

It further falls to 106 in the following age period of 11–15 years, that is 10·19 per cent. of the total cases, and the number of male and female cases in these two age periods are about equal.

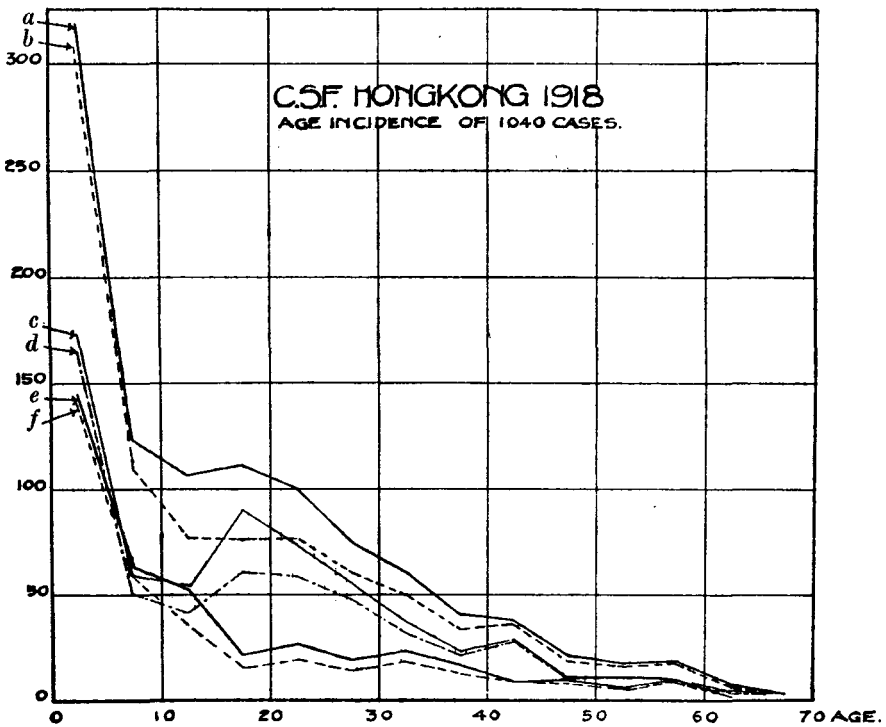
In the reports of the New York epidemic of 1905–6–7 the number of children under ten years affected is said to be 67 per cent., 65 per cent. and 68 per cent. of the total cases affected in these three respective years. In Hong Kong the returns for less than four months show that 441 cases, or 42·40 per cent. of the total cases occurred among children under ten years.

In the 16–20 period the number rises slightly to 111 cases, or 10·6 per cent. of the total. This number is made up of 90 male cases, 21 female cases, as shown in Chart No. 1, where the lines representing the numbers of male and female cases diverge widely at this point.

¹ Sophian. *Epidemic Cerebro-spinal Meningitis*, 1912.

The number of cases gradually diminishes during the following age periods until that of 66–70 years, where it is represented by three males with a mortality of 100 per cent.

It has been frequently stated that cerebro-spinal fever is a disease to which young adult males are peculiarly susceptible and at first glance it would appear to be borne out by the figures in Hong Kong (Chart No. 1). It is a well-known fact that the Chinese population in Hong Kong is composed largely of males. In the last census taken in Hong Kong in the year 1911, it was found that Chinese males over 15 years formed 54 per cent. of the total Chinese population, and on comparing the numbers in the census table given for males and females



a, Total cases: b, Total deaths: c, Male cases: d, Male deaths: e, Female cases: f, female deaths.

Chart 1. Graph showing mortality, age and sex incidence in 1040 cases.

during the respective age periods it is found that for the age period 16–20 years there are 31,290 males and only 12,913 females. It would naturally be expected that there would be more cases of cerebro-spinal fever among the larger number of males at this age than among the smaller number of females.

The census for 1911 is the nearest approach to accuracy obtainable, but only a census taken at the actual time of the epidemic could be held to be accurate, owing to the migratory nature of the population in Hong Kong.

In Chart No. 2 the age incidence of the total cases has been represented in percentage of the population as given by the last census taken in 1911. In

this chart the susceptibility for adult males of 16-20 years as shown by the peak in Chart No. 1 is no longer evident. It is wiped out when the peculiar local conditions as to population are taken into account. From 55-60 years there is apparently a rise in susceptibility more especially in the female, but the number of cases which occurred at this age is so small that no generalisation can be drawn beyond the one that susceptibility increases slightly with old age. The curve representing male and female cases in Chart No. 2, cross and recross and nothing definite as to sex incidence can be deduced.

It would appear then, taking both these charts into account, that under five years is the most susceptible age, after which the susceptibility drops 38 per cent. and diminishes gradually to old age, when it again shows a slight

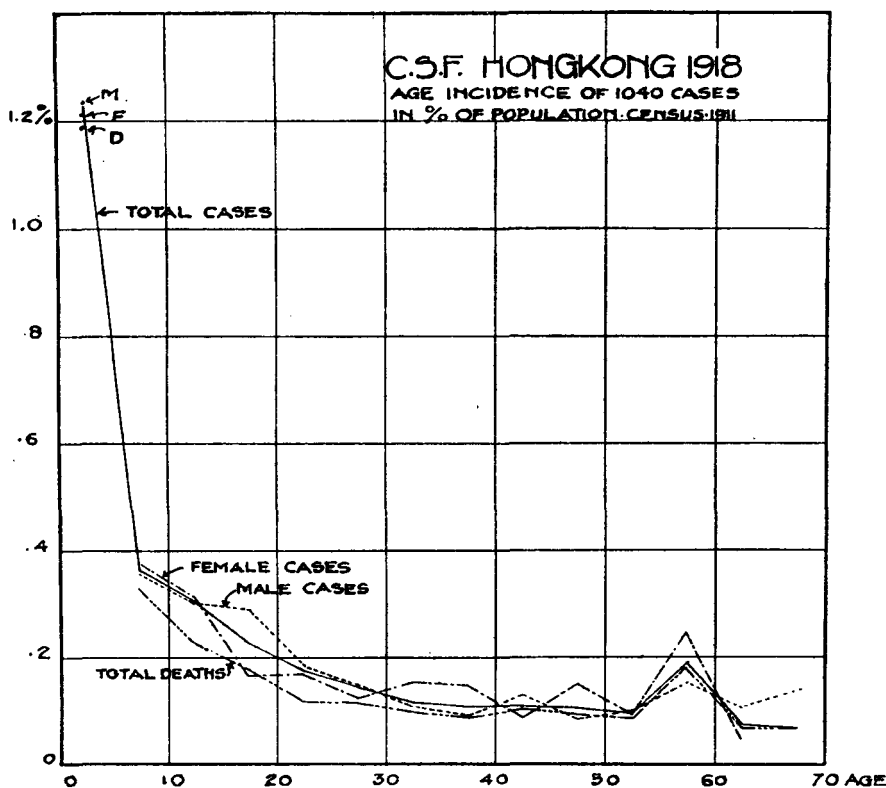


Chart 2. Graph showing mortality, age and sex incidence in 1040 cases represented in percentage composition of the population according to the census of 1911.

increase. Speaking generally the younger the individual, the greater the susceptibility with the added proviso that the extremes of life suffer most.

Incidence among Europeans. Out of 1040 cases only four European cases were notified between the onset of the epidemic and June 1st, three of which proved fatal. About ten days after the epidemic was recognised the first European case occurred in a middle aged business man in a debilitated state of health who succumbed to the attack in about three days.

Two English ladies, also in a low state of health, formed the second and third European cases, separated in time by a few weeks. The relatives of these two patients were strongly of the opinion that infection was the direct result of a shopping expedition to the Chinese part of the town undertaken two days previous to the attack. Both cases proved fatal after a very brief illness.

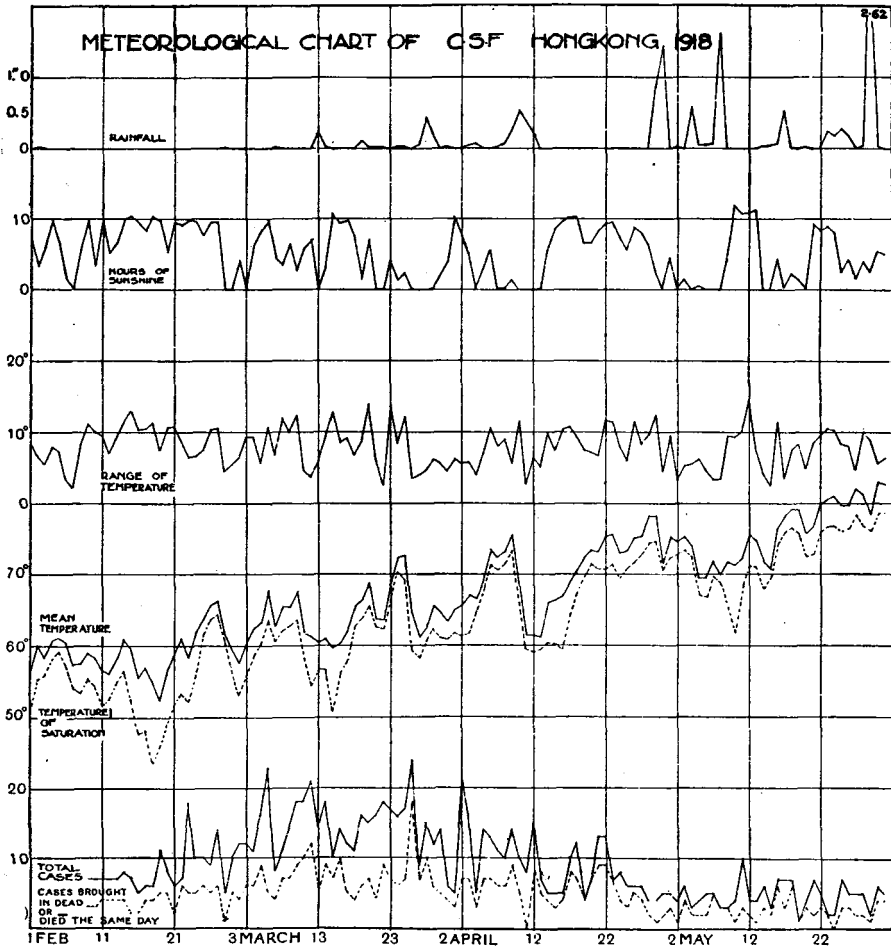


Chart 3. Showing relationship of daily number of cases of cerebro-spinal fever to the meteorological conditions.

The fourth case was that of an English schoolboy who fell ill during the holidays. He lived in a European Hotel and several members of his family and several of the Chinese servants were afterwards found to be carriers. After a protracted illness he recovered.

III. METEOROLOGICAL CONDITIONS.

The view that the onset of the disease was affected in some way by the meteorological conditions has been held by many observers, but the conclusions reached have been of a widely divergent nature.

Foster and Gaskell¹ write as follows: "Among the cases with which we had to deal in this outbreak, there appeared to be a certain relationship between a rapid fall of the barometer and the onset of the disease.... The conclusion may therefore be drawn that bad weather conditions alone are not the chief predisposing cause; rapid daily variations of temperature with or without much rain are of far greater importance."

Worster-Drought and Miles Kennedy² state that "There appears to be some connexion between diminished rainfall and an increase in the case incidence of the disease," and again, "There is no apparent relation between low atmospheric temperatures and cases actually suffering from the disease."

Compton³ is of the opinion that "Cerebro-spinal fever is a weather disease, outbursts being associated with sudden saturation of the atmosphere by water vapour combined with equable conditions of temperature—the meningococcus being about."

In Hong Kong, owing to the size and localised nature of the epidemic and the existence of an observatory from which accurate meteorological data could be obtained, an excellent opportunity was afforded for obtaining material on which reliable conclusions could be based. I have to thank Mr Claxton, Director of the Royal Observatory, Hong Kong, for furnishing early information of all meteorological returns.

With regard to the meteorological conditions in Hong Kong and their influence on the course of the epidemic, it would appear from analysis of the charts that once the epidemic had started, temperature had the most important influence on its course. It is observed that the curve of the daily incidence of cases follows a remarkably wavy course. The four highest peaks of this curve are sharp, and in each case represent an incidence of over 20 cases per day. Upon investigating the weather charts to ascertain if any connexion existed, it was found that certain meteorological conditions were constant for each one of these four peaks.

1. Looking at the first of the high peaks which occurred on March 6th and represented 23 cases, it was observed that on the fourth, fifth, and sixth days before this date the mean temperature showed a drop of 9° F. over three days, or 3° drop per day. On these three days the mean wet and dry bulb temperature curves approach each other, registering 2°, 3°, and 4°, difference respectively, showing that with the falling temperature the air was very moist. This was associated with a low range of temperature of 6°, 5°, 4°, per day respectively, and a complete absence of sunshine on the fifth

¹ *Cerebro-spinal Fever*, pp. 129–130.

² *Cerebro-spinal Fever*, 1918.

³ *Lancet*, 1917, xi. 15.

and sixth days and four and a half hours on the fourth day. No rainfall was recorded and the mean wet bulb temperature showed a drop of $11\frac{1}{2}^{\circ}$ F. over the three days.

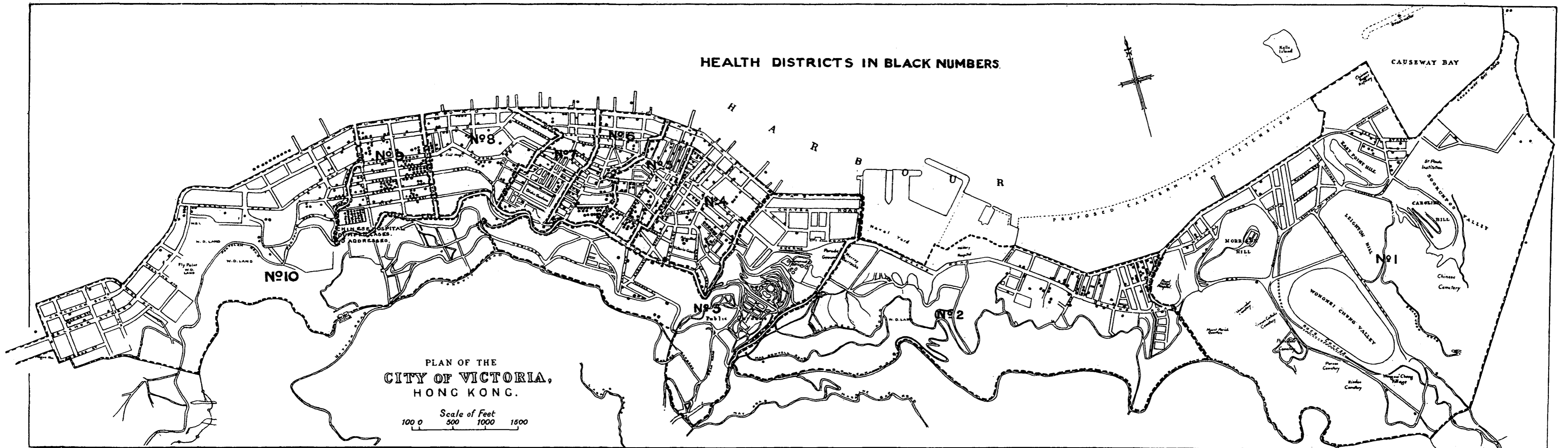
2. Taking the next peak in order, 21 cases, which occurred on March 12th, it is observed that five days before this there was a drop in the mean temperature of 5° F., that the difference between the mean wet and dry bulb temperature registered only 2° F. The range in temperature dropped from 11° to 6° , and the hours of sunshine from nine and a half to four hours.

3. Coming to the third and highest peak of all, which occurred on March 26th, representing a total of 24 cases (18 of which were brought in dead, or died the same day), it is observed that five days previous to this the mean temperature dropped 5° F., the mean wet bulb temperature dropped 3° F. and remained at this temperature for two days, the fourth and fifth day before the peak, and during this time the difference between the mean wet and dry bulb temperature was only 1° F. On these same two days the range of temperature had dropped to 6° and 3° respectively and there was no sunshine registered in the colony. Rain fell on these two days to the extent of about .05 inch.

4. With regard to the last of the four high peaks on April 2nd, when 21 cases (seven dead) were reported, it was noted that a drop of $3\frac{1}{2}^{\circ}$ and 8° F. in the mean temperature, and 1° , and 10° F. drop in the mean wet bulb temperature occurred on the sixth and seventh day previous to the peak. The difference between the mean wet and dry bulb temperature was $2\frac{1}{2}^{\circ}$ on the sixth day and 5° on the seventh day. The range of temperature was 3° on the sixth day and 4° on the seventh day, and the hours of sunshine were nil on the sixth and seventh days respectively. The rainfall on these two days was also nil.

By comparing the charts further it is evident that practically every peak in the case incidence chart is represented by a corresponding depression on the temperature chart, ante-dated by a few days. This is specially noticeable towards the latter end of the epidemic when, on April 9th and 10th the mean temperature and the mean wet bulb temperature dropped 14° F. over the two days, approximating to within 2 degrees of each other and remained at this—for the time of the year—low temperature for three days following, viz. April 11th, 12th and 13th, accompanied by a complete absence of sunshine, with the result that on April 17th and 18th the incidence of cases rose from the previous average of five daily to that of 10 and 12 a day, forming the peak shown on the curve on April 18th.

A similar instance is noted on May 11th, when 10 cases were reported after a week in which the highest daily number did not rise above five cases. This was associated with a drop in the mean dry and wet bulb temperature, saturation of the air as shown by the approximation of these two temperature curves, low range of temperature and practical absence of sunshine on the fifth, sixth and seventh days previously, viz. May 4th, 5th and 6th. This interval or lag is thus shown to increase as the epidemic progresses and varied from three to four days in February to five, to six, to seven days in April and May.



Map I. Spot Map of the cerebro-spinal fever cases in the city of Victoria, showing the health districts marked out by irregular lines and numbered No. 1-No. 10.

Cambridge University Press

Conclusions to be drawn as to the influence of meteorological conditions. It is evident from this analysis that:

1. Temperature showed the most influence. A drop in the temperature being invariably followed after a lag of a few days, by a rise in the number of cases. This lag tends to increase from three to four days at the beginning to six to seven days at the end of the epidemic.

2. That this fall in temperature was found to be associated with the following conditions:

(a) Steady maintenance of the low temperature as shown by the low range of temperature.

(b) Saturated condition of the air as shown by the approximation to each other of the wet and dry bulb temperatures.

(c) Absence of or diminution in the amount of sunshine.

3. That the rainfall showed no appreciable effect.

IV. GEOGRAPHICAL DISTRIBUTION AND OVERCROWDING.

The island of Hong Kong has an area of about 32 square miles and the city of Victoria situated on the northern side of the island has a frontage on the sea of nearly five miles and is separated from the Kowloon portion of the colony by the harbour (Map I).

That portion of the mainland between the shore and the Kowloon Hills known as Kowloon, has a seaboard of about 13 miles and an area of about 16 square miles (Map II, p. 300).

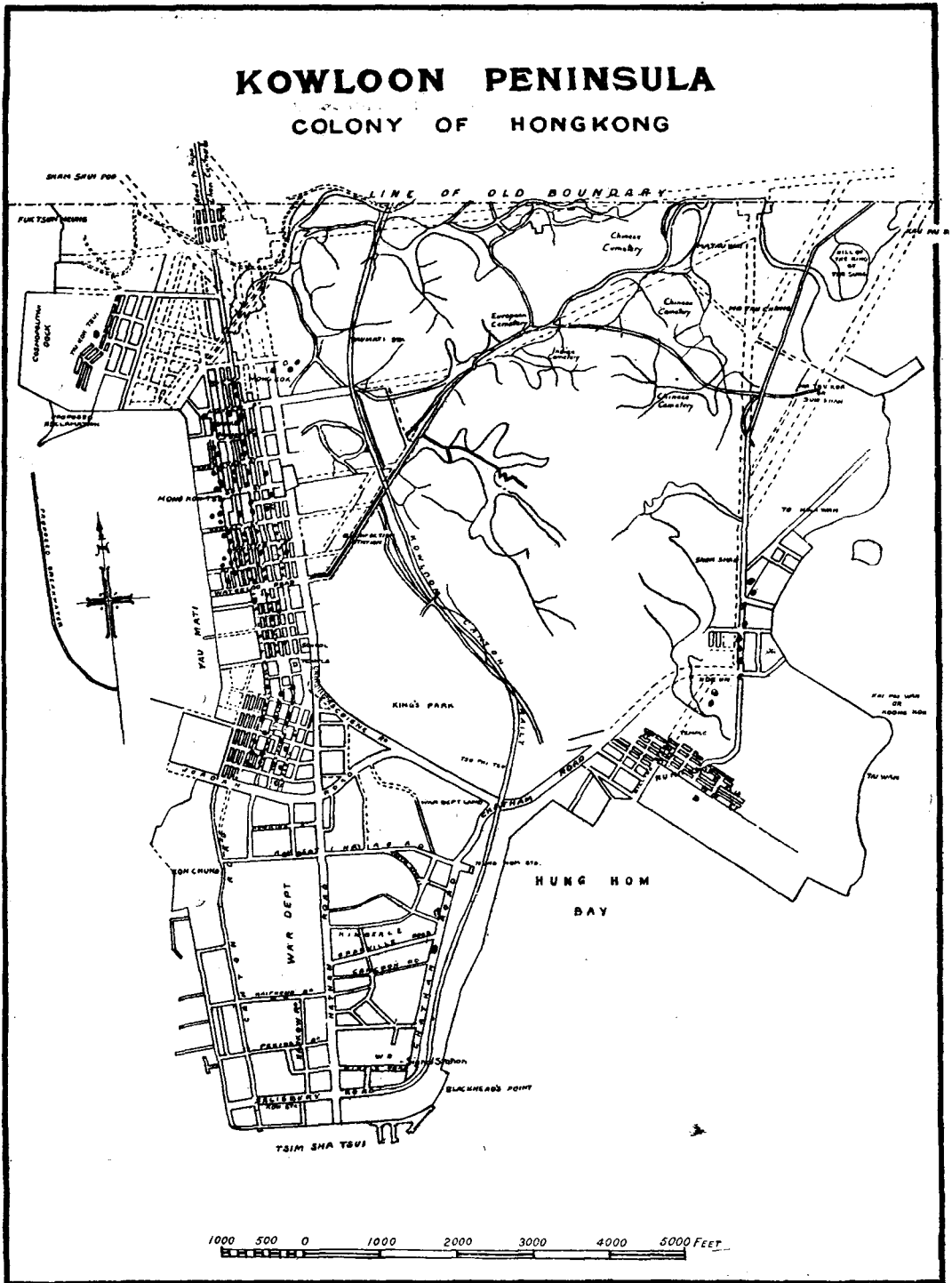
In the Annual Report of the sanitary board for 1917 the distribution of the population estimated to the middle of 1917 was as follows:

Non-Chinese civil population	...	13,500
Chinese civil population:		
City of Victoria (including Peak)	280,700	
Villages of Hong Kong 15,300	
Kowloon (including New Kowloon)	77,200	
New territories (land) 89,900	
Population afloat 58,500	
Total Chinese population	521,600
Total civil population	535,100

The following comment was appended to this table:

These figures have been estimated by the usual method based on natural increase as shown by the Census returns of 1906 and 1911 to which the number 10,000 has been added to allow for the influx of Chinese due to disturbances in Keong-tung Province.

There is no means of estimating the number of Chinese in the colony at any given time except by a Census and until a new Census is taken the present estimated figures must be considered to be quite unreliable and are in all probability much too low.



Map II. Spot map showing position of cerebro-spinal fever cases in the Kowloon Peninsula.

In the Sanitary Board Report for 1916 the head of the sanitary department states as follows:

The population has been so much disturbed by frequent immigration of Chinese refugees that too much reliance should not be placed on these figures. It is estimated that there were 120,000 such refugees in the colony at one period in 1916.

It is evident then that the total Chinese population of 521,600 as estimated for the year 1917 with a population of 280,700 estimated for the city of Victoria is much too low. More especially is this the case for Victoria where, in certain portions of the town, the streets, lanes and houses are so filled with people in the day time that it seems almost impossible to find a passage way.

The built over area in the city of Victoria is stated in the Sanitary Report for 1916 to be 802 acres which taking the population at 280,700 as estimated for the year 1917 would give an average density of 350 persons per acre.

It is stated in this report for 1917 that there are in the city of Victoria 9921 Chinese houses with an average of 3.1 floors per house. As the Chinese population for the city of Victoria is estimated for the year 1917 at 280,700 this would give an average of 28.8 persons per Chinese house. The average number of floors being 3.1 per Chinese house, this works out an average of nine persons per floor in each Chinese house.

In the Sanitary Report of 1916 a table is given showing the acreage of the city health districts with the houses and civil population estimated for each district.

In this table these health districts which showed the greatest density were No. 9 with a density of 863, No. 6 with a density of 981, and No. 5 with a density of 1000 persons per acre. A comparison with the state of affairs as recorded in the census year of 1911 is given in Table B.

Table B.

Year	Population, city of Victoria	Average number of persons per floor	Density per acre			
			Average	No. 9 H.D.	No. 6 H.D.	No. 5 H.D.
1910	178,300	6.9	252	578	615	693
1911	219,386	8.3	303	727	800	956
1916	270,300	8.7	352	863	981	1000
1917	280,700	9	350	No information		

Density per acre. In the Sanitary Report of 1911 compiled after the census was taken, it is stated that the population for the city of Victoria was 219,386, that the average number of persons per floor per Chinese house was 8.3; the average density for the town being estimated at 303 per acre.

Upon comparing the estimates for the years 1910 and 1911 as given in Table B, it is noted that the city of Victoria was growing out of all proportions to the estimated ratio of increase.

Thus in 1910 the average number of persons per acre was estimated at 252 and the following year it was found at the census to be actually 303 persons per acre, while the average number of persons per floor per Chinese

house had risen from 6·9 in 1910 to 8·3 in 1911. It is obvious from this that, prior to the last census, the authorities were in ignorance as to the extent of overcrowding then existing.

In these most overcrowded health districts in Victoria the extent of this ignorance is shown by comparison of the figures as given in Table B for the years 1910 and 1911, where the margin of error was in No. 9 Health District 149, and in No. 6 Health District 185, and in No. 5 Health District 263 persons per acre.

For the year 1917 the average number of persons per floor per Chinese house is estimated at nine, a figure which would mean an increase of about ·7 persons per floor in the last six years.

As this calculation is based on the population estimates for the year, which are admittedly unreliable and much too low, the probability is that this figure should be considerably higher and that the next census will show an even more remarkable margin of error in the estimated figures than the last census.

If it be accepted that the "true index of density is the number of persons to each occupied room," and that "this test combined with a determination of the population in a given area would give the most trustworthy estimate of density¹," it is highly probable that Hong Kong, in the next census, will head the list for overcrowding in any British community.

Migration of the population. Migration is of considerable importance from the public health aspect in this epidemic.

Hong Kong is characterised by the large migratory section of the Chinese population which comes and goes practically unheeded. The migratory population is made up as follows:

1. Chinese emigrants leaving Hong Kong for ports other than China. The numbers are given in the Blue Book as follows:

In 1917 96,295.

Chinese emigrants returning to Hong Kong from ports other than China:

In 1917 98,232.

2. The known passenger traffic between Hong Kong and the mainland of China. The numbers are as given in the sanitary reports:

(a)	For year 1917.	By river steamer.	Arrivals ...	870,837
			Departures ...	844,480
(b)	,,	,,	By rail.	Arrivals ...
			Departures ...	309,394.

This number includes some European traffic, but the number is negligible in comparison with the Chinese traffic.

3. Unknown passenger traffic between Hong Kong and China. This is, even in war time, an unknown quantity, as junks and sampans containing entire families of three generations arrive and leave Hong Kong daily unhampered.

Adding together these figures, it is found that 1,321,077 people arrived in

¹ *Vital Statistics*, by Sir A. Newsholme.

Hong Kong and 1,250,172 people departed from Hong Kong during the year 1917.

These figures are mainly Chinese, but include some little European traffic on the river steamers and railway, but do not include the passenger traffic on 750 ocean-going steamers stated, in the Blue Book for 1917, to have visited the colony at varying intervals of time during the year.

This large number of new entries into the colony, introducing, as it does, fresh susceptible material for the spread of infection, has a considerable bearing on the extent of the epidemic, as will be shown later.

The migratory nature of the population no doubt plays an important part in the dissemination of the disease, for in March an outbreak of 60 cases occurred at Swatow, a neighbouring coast port about a day's journey from Hong Kong. The first case which occurred in Shanghai was a European who had been to Hong Kong for race week at the end of February, and developed cerebro-spinal fever shortly after his return to Shanghai. A few cases only occurred in Shanghai, but it was well known that there was a big attack in Kobe, Osaka and Tokyo, although no official information was received from the Japanese.

It has been pointed out by Lieut. P. K. Olitsky in his report to the Hong Kong Government that the "entrance of a new susceptible element of population from a non-infected district into the epidemic area of the colony and this new element, usually coolies, existing in close contact with the disease, will tend to increase the number of cases: or they will cause a disturbance of the insusceptible ratio of the normal native population, and when the cold season approaches, or under other conditions favourable to the spread of epidemic meningitis, these will be new soil for an outbreak."

Dr Reynolds, the Medical Officer of Health for Canton, which lies on the West River, about 90 miles from Hong Kong, reported that there was no epidemic of cerebro-spinal fever there during the winter of 1918, and that the few cases which did occur were all recent arrivals from Hong Kong. This bears out experience in America where, during the epidemic in New York in 1904-1905, Philadelphia, less than 100 miles distant, was not attacked.

Housing conditions in Hong Kong. Some idea of conditions as they exist in Hong Kong may be obtained from the following quotations from old sanitary reports to the Government.

In the report on the question of the housing of the population of Hong Kong, by O. Chadwick, A.M.I.C.E., C.M.G., in 1902, he writes as follows:

"(1) The insanitary areas in Hong Kong have been formed by the crowding together of too many houses on too small a space.

(2) By sanitary defects in the design of dwelling houses.

(3) By overcrowding of the inhabitants of these houses. The crowding together of too many houses on too small a space has been effected by the construction of narrow streets and lanes and by the omission to provide adequate open space in the rear of houses in the shape of back yards and of back lanes. The houses have been brought into close proximity to one another instead of being well separated with ample space between them. The conditions vary in intensity according to the age of the built-over areas. The worst conditions are to be found where back-to-back houses have been constructed, or where the lane

between the rear of houses is not more than 6–8 ft. wide. In either case neither light nor ventilation is accessible from the back while only a very inadequate amount is obtainable from the narrow street or lane in front owing to the height of the houses being out of all proportion to the width of the street or lane. Similar unhealthy conditions occur when the rear of the houses abuts on the hillside with the additional circumstance that the house is rendered damp during the rains from percolation of water from the hill.

The Chinese tenement houses in Hong Kong differ in style from the European. They also differ from the ordinary Chinese houses in Canton or other Chinese city where the buildings are not more than two storeys in height, often not more than one. By some gradual process of evolution they have taken on the worst features of both kinds of houses and none of their best. The tenement houses in Hong Kong consist of several storeys, each storey containing one long room lighted at each end by a window but without lateral windows. Each room is subdivided by 6 ft. high partitions into cabins called cubicles, which accommodate an entire family. The room on each floor communicates in the rear by a bridge with the kitchen which is separated from the house by a small yard; and in front with a masonry verandah which encroaches on the public street and, which being separated by partitions from the adjoining houses is used as an additional room for the house.

The length of room without lateral windows, the kitchen buildings in the rear and the smallness of the back yard, by obstructing the free access of light and air, cause the two lower storeys at least to be dark and badly ventilated.

The verandahs in front still further increase this undesirable condition and the cubicles in the room intensify it to such an extent that none of the rooms are healthy habitations. The cubicle system leads to overcrowding in its worst form, and with the absence of light and fresh air, under its worst conditions, for with the existing design of buildings wherever there are more than two cubicles in a room, even in the upper storeys, the compartment is dark and devoid of fresh air. With darkness, absence of fresh air and overcrowding, it is impossible to keep them clean.”

This condition of affairs, condemned by Mr Chadwick and Prof. Simpson in 1902, holds good to-day, but in an aggravated form, owing to the unknown extent to which the population has increased. An attempt was made in the early days of the epidemic to get permission roughly to estimate to what extent overcrowding did exist, by surprise night visits of the sanitary staff to the most overcrowded parts of the town, or even to those houses in which a case of cerebro-spinal fever has been reported. It was considered by the Government that this would annoy the Chinese community and permission was thereupon refused, and all idea of finding out the actual state of affairs had to be abandoned, except in so far as information could be obtained from the usual daily visits of the sanitary inspectors.

It was possible in 578 instances to get the number of persons said by the tenants to occupy the floor (or room) in the house in which the case occurred. The results have been tabulated as follows:

Number of inmates on one floor	No. of inspected floors	Percentage of total	No. of floors in which two cases occurred
1– 5	116	20	3
6–10	154	26.6	11
11–15	156	26.9	10
16–20	97	16.7	11
21–25	40	6.9	5
26–30	9	1.5	0
31–35	6	1	0
	578	99.6	40

From this it is found that 53·4 per cent. of the houses investigated of one floor and one room in which cases of cerebro-spinal fever occurred had more than ten occupants admitted to by the tenants. For the purpose of this table each child was calculated as one person, but it was quite exceptional for the tenants to admit that more than two or three children slept on the premises, and any excess over this number in the rooms were said to be children of friends on a visit.

Acting on the supposition that the above figures are accurate in so far as they do not overstate the case, it is found that 97 floors, or 16·7 per cent. of the available estimated floors contained from 16–20 inhabitants per floor, and that 40 floors, or 6·9 per cent. contained 21–25 inhabitants per floor.

Those houses which contained from 26–35 inhabitants were matsheds, or else converted godowns, subdivided into a large number of small cabins, in which, although the overcrowding was serious, yet the ventilation and lighting were distinctly superior to that of the smaller houses, which may account for the fact that no double cases occurred in these houses.

Out of these 576 floors it was found that 40 floors, or 6·92 per cent. gave double cases, and that 18 out of these 40 floors (or 45 per cent.) of the houses giving double cases were situated in No. 9 health district. In addition, in five other instances, three cases came from the same address, but on investigation it was found that four of these addresses were matsheds, temporary structures erected mainly for housing large numbers of coolies engaged on building operations. The remaining instance was that of a Chinaman who, with his wife and five children, arrived in the colony on February 15th and went to live under fair housing conditions in No. 4 health district, in a respectable Chinese boarding-house from which no previous case of cerebro-spinal fever had been reported. During the earthquake which occurred in Hong Kong on February 15th, he and his family all rushed with others out of the building into the streets, which were packed with frightened Chinese. Two days later, on the 17th, the Chinaman and his daughter, a sickly child, were removed to a private hospital and both died there on February 19th of cerebro-spinal fever. The nature of the illness was not detected during life. The wife of this man, who had remained with her husband until he died, was removed to a Government hospital on February 21st, and she died therein of cerebro-spinal fever on February 24th, 1918. Two cases were reported from the first floor of No. 12 First Street, in No. 9 Health District, which measured 38 ft. in length, 13·3 ft. in width and 12 ft. high, but contained no wooden cubicles and was occupied by 23 people including three children. That is to say, there was an allowance of 21·9 sq. ft. of floor area per person, counting each child as one, or of 23·5 sq. ft. of floor area counting each child as one half an adult allowance. As the Public Health Ordinance, Hong Kong, provides that 30 sq. ft. of floor area is the minimum allowance per head where no cubicles exist, and 50 sq. ft. where cubicles exist, this case is an obvious infraction of the law.

In a similar case in No. 9 Health District at 20 Fish Street, third floor, where

three cubicles without windows and two legal rooms or cubicles with windows existed, the total measurements of the floor were 39 ft. 4 ins. by 13 ft. 6 ins. by 17 ft. 6 ins. high. This floor supplied two cases of cerebro-spinal fever and was admitted by the tenant to contain 20 inmates, four of whom were children. The floor area works out at 26.5 sq. ft. per head, counting each child as an adult, or 29.4 sq. ft. per head, counting two children as one adult. But even on discovery of this gross infraction of the law the sanitary department was unable to take any action in the matter.

It is the custom among the Chinese to bolt every window and lock every door, as a precaution against thieves, and as there is no fireplace in a Chinese house, except in the kitchen, there is an absolute lack of ventilation and the consequent foul state of the air is indescribable.

An attempt was made to estimate the influence of the number of cubicles in a house on the case incidence during the epidemic, but no information of any value was elicited. It was found that:

Houses with 1 cubicle gave	17.6	per cent. of the total cases.			
„ 2 cubicles gave	21.5	„	„	„	„
„ 3 „ „	21.2	„	„	„	„
„ 4 „ „	12.3	„	„	„	„
„ 5 „ „	9.3	„	„	„	„
„ 6 „ „	4.1	„	„	„	„
„ 7 „ „	1.0	„	„	„	„
„ 8 „ „	.6	„	„	„	„

For the remaining 12.4 per cent. there were no cubicles, or else no information.

The majority of domestic Chinese houses in Victoria have more than one cubicle. It would appear that the houses with one cubicle have no great advantage over those with two or three. Cubicles are pulled down one day and erected again the next, therefore no correct list of houses with the respective number of cubicles was available. It must not be forgotten that in a Chinese house, in addition to the cubicles, there are beds all down the free wall space, and often a second layer of bunks half way up to the ceiling, and that each of these bunks or beds may be screened by a sackcloth or rag curtain hanging on a string, and may contain a family of varying number.

Spot map (see p. 300). The spot map shows, even to the casual glance, that in this epidemic there was a tendency previously noted in other epidemics, for the cases to arrange themselves in groups. In the outskirts of the town the groups are smaller and more widely separated, and in the centre of the town the groups are larger and more closely associated. On comparing the number of spots, or cases, in a given area over those parts of the town in which the spots appear to be most closely packed, the following results were obtained:

In No. 9 Health District, taking an area of 500 ft. sq. south of Queen's Road, between Centre and Eastern Street, this was found to contain 43 cases, or

4.1 per cent. of the total number. In the similar area immediately adjoining, lying between Centre and Western Street, there were 25 cases, or 2.4 per cent. of the total number. In No. 6 Health District, in the area 500 ft. sq., north of Caine Road, between Pedder Street and Sing Wong Street, there were 27 cases, or 2.6 per cent. of the total. In No. 5 Health District, in the area 500 ft. sq., south of Hollywood Road, lying between Peel Street and Sing Wong Street, there were 31 cases, or 2.98 per cent. of the total number. In Wanchai and Kowloon the largest number of cases in any area of 500 ft. sq. was found to be 20, or 1.92 per cent. of the total number.

In No. 9 Health District, taking an area of 1000 ft. sq. lying between Eastern and Western Streets, extending from Des Voeux Road to High Street, it is found that 100 cases, or 9.6 per cent. of the total cases were resident in the streets included within these boundaries. Twelve of these cases came from six floors. Taking the next most crowded areas of the same size, situated partly in No. 6 Health District and No. 5 Health District, north of Caine Road, lying between Real Street and Ladder Street, there were found to be 80 cases, or 7.6 per cent. of the total. Four floors in this district gave six cases. In a similar area situated partly in No. 6 and No. 7 Health Districts, extending from Queen's Road to Caine Road, lying between Sai Street and Sing Wong Street, there were found to be 63 cases, or 6 per cent. of the total number. Four floors in this district also gave eight cases. In Wanchai, in No. 2 Health District, and other parts of the town where the cases were more widely separated the largest number of cases in a similar area works out at about 2.3 per cent. of the total.

In Kowloon, in Mong Kok Tsui, the number rises to 4 per cent. of the total, but neither in Kowloon, or in Wanchai did any one floor give more than one case. In one instance in each of these two districts two cases were reported from the same tenement but different floors.

The small Chinese hospital for children in High Street, No. 9 Health District, gave, in addition to many other cases traced to their homes, a record of 43 cases in which a wrong address had been given and no trace of the family could be obtained. No doubt many of these cases came from the houses in the immediate neighbourhood.

From these results it is seen that the area in No. 9 Health District lying between Eastern and Western Streets, more especially towards the Eastern Street end contained the largest number of cases. This district is said to have a density per acre of 727 in the 1911 sanitary report, which, being the report of the census year, is presumably reliable for that year. For the year 1916 the density is said to be 863, which is quite unreliable and for the before-mentioned reasons is probably much too low. In any case, however, No. 9 Health District is well known locally to be the most overcrowded portion of the colony.

This is borne out by the following incident. On one occasion during the course of the cerebro-spinal fever epidemic a number of influential Chinese visited the Sanitary Board Office, in order to see the spot map, and the spokes-

man of the company asked to see first, the area lying between Eastern and Western Streets. After some study of the map, this Chinese gentleman said, "Yes, it looks as if overcrowding had something to do with this disease, judging by the numbers of spots in First Street, Second Street, Bridges Street and Staunton Street." These streets were well known to him to be the most crowded portions of the colony.

It is interesting to note that the three health districts in Victoria, viz. Nos. 5, 6 and 9, found at the last census to be the most grossly overcrowded, yield in the epidemic of cerebro-spinal fever the largest number of cases. From the census returns, it would have been expected that the order of the maximum incidence of cerebro-spinal fever would have been, first, No. 5 Health District; second, No. 6 Health District, and third, No. 9 Health District, whereas it was found that the results were—first, No. 9 Health District, second, No. 5 Health District, and third, No. 6 Health District. But No. 9 Health District is popularly supposed to be the most overcrowded portion of the town and it supplied 9·6 per cent. of the total cases, and the highest number of houses giving more than one case, so it may reasonably be expected that the next census returns will show No. 9 Health District to possess the greatest density per acre of any of the health districts in Victoria.

The general conclusion to be drawn from a careful study of the Spot Map is that the number of cases of cerebro-spinal fever in any given area varied directly with the overcrowding in that area, and that this bears out the generally accepted statement that overcrowding is one of the most important features in the epidemiology of cerebro-spinal fever.

V. HABITS OF THE CHINESE.

The well-known habit of the Chinese to expectorate profusely and constantly indoors and outdoors may be considered to have some relationship to the spread of cerebro-spinal fever in the colony. Expectoration among the Chinese lower classes consists of clearing the naso-pharynx by way of the mouth. The Chinese, as a nation, do not use handkerchiefs and, from their point of view, do not require them.

Taking this in conjunction with the fondness of the Chinese for eating in the streets, at little cooking stalls, or hawker's kitchens, food which has been exposed for some time in the open air and served in dishes which are only very occasionally washed and then dried with a filthy towel, which may have been used for several other unhygienic purposes, it is obvious that there is ample opportunity for conveyance of infection by food and food utensils. In addition, there is much drying and sorting of food on the streets and pathways all through the city.

VI. LENGTH OF RESIDENCE IN THE COLONY.

At the time of onset and during the course of the epidemic, enquiry was made into the length of time each case of cerebro-spinal fever had been resident in the colony previous to the first day of illness. The following table is an analysis of the results:

Table C.

	Length of residence previous to onset of cerebro-spinal fever	No. of cases	Percentage of total cases per day	Percentage of total cases per week
First week	1 day	19	1.8	9.5
	2 days	23	2.2	
	3 "	32	3.0	
	4 "	9	.8	
	5 "	5	.4	
	6 "	4	.3	
	7 "	11	1.0	
	1-2 weeks	50	.68	4.8
	2-3 "	104	1.42	10.0
	3-4 "	142	1.9	13.6
	Over one month	567	—	54.5
	No information	74	—	7.1
		1040	—	99.5

From this analysis the very interesting result is obtained that out of the total number of cases 7.1 per cent. had been resident three days, or less, and 37.9 per cent. one month, or less, in the colony when attacked by the epidemic.

It would appear that case incidence was high among the recent arrivals in the colony. Thus 9.5 per cent. of the total number of cases had only been resident in the colony one week, or less, and 3 per cent. of the total only three days when attacked by the disease. The numbers fell during the second week, rose again in the third week to a little above the level of the first week, and then increased to 13.6 per cent. for the fourth week of residence. It is evident from these figures that susceptibility in recent arrivals is high for the first three days, reaching its maximum on the third day, that it then falls for three days, after which it rises gradually, until in the fourth week of residence it reaches the average of 1.9 per cent. of the total cases for each day of the week.

The very high case incidence occurring in arrivals of three days' standing may have some relation to the period of incubation, which, although generally accepted to be from one to five days, might be held to be one to three days, with a special predilection for the third day.

Flexner¹ states "that the unusual conditions surrounding the military life exert an influence at the outset is indicated by the circumstances that it is the fresh recruit and not the seasoned soldier who especially suffers from epidemic meningitis."

It would appear then that the fresh Chinese recruit to Kong Hong is also

¹ "Control of Meningitis," in *Journal of the American Medical Association*, Aug. 24th, 1918.

especially liable to suffer from cerebro-spinal fever, and this is interesting, as overcrowding in sleeping quarters is probably the only condition common to life in a military camp and Chinese social life as it exists in Hong Kong.

Fildes and Baker¹ point out that when a case of cerebro-spinal fever occurs it is because a susceptible person is in contact with a high proportion of carriers and that new entries are specially prone to this disease. They consider that this etiological factor is more important than youth. In Hong Kong the high case incidence among recent arrivals is probably the result of the ideal conditions for the transmission of the disease which existed at this time in the colony. These may be tabulated as follows:

1. The large number daily of known cases and problematical number of missed cases.
2. The high proportion of carriers which no doubt existed during the epidemic.
3. The extremely migratory nature of a large proportion of the population which would entail a large daily influx of susceptible individuals from epidemic free areas.
4. Meteorological conditions.
5. Gross overcrowding in sleeping quarters in damp, insanitary, unventilated houses.

VII. OCCUPATION INCIDENCE.

An attempt was made to ascertain the influence, if any, of occupation on the incidence of the disease and an analysis was made of 336 adult cases in which it was possible to obtain information. The results were as follows:

Table of occupation incidence: 336 cases.

Occupation	No. of cases	Percentage
Coolies	117	34·82
House servants ...	44	13·09
Cooks	21	6·25
Students	18	5·35
Hawkers	11	3·27
Carpenters	11	3·27
Constables	7	2·08
Various	107	31·89
	336	99·92

Under the heading of "Various" is included 45 occupations, not one of which was represented by more than four cases.

In spite of the large number of clerks and office boys in the colony, it was noticeable that only four cases out of 336 occurred in this section of the populace.

The coolie, or unskilled labourer, forms a large proportion of the population in Hong Kong and lives a life of hard muscular fatigue, for everything that is

¹ *Report upon the Seasonal Outbreak of Cerebro-spinal Fever in the Navy at Portsmouth, 1916-1917*, Medical Research Committee, Special Report, series No. 17.

required in the colony, furniture, coals, or building material, is carried to its destination on the shoulders of the coolie, even if that destination should be 1500 ft. up on the Peak. This, taken in conjunction with the fact that the coolie belongs to the poorest class and therefore lives in the worst houses, under the most overcrowded conditions, is probably sufficient explanation why the coolie class of the population should furnish 34.82 per cent. of the cases of known occupation.

The comparatively large number of house servants affected might be explained as follows:

House servants in better class houses occupy coolie quarters at the back of the house and the majority of them keep their families in the country. Some of them, however, keep their wives and families in cubicles in the overcrowded portions of the town, where they visit them by night.

Many comparatively well-off Chinese live under poor housing conditions and keep a servant, or slave girl, who is housed in a bed under the stairs, or some odd corner in the passage way.

Cooks and students furnish a somewhat unexpectedly large number of the cases. The cooks were, for the most part, engaged in work in Chinese restaurants, and the theory that infection might be conveyed by food, or feeding utensils, would appear to receive some support from this high case incidence in Hong Kong. The comparatively large number of Chinese students affected is somewhat surprising but might be explained by the habits and poverty of this class.

Speaking generally, this analysis of occupation incidence goes to prove that it is the poorest, most hard worked and worst housed classes of the population that suffer most, and that if the doubtful case of cooks be excepted, occupation *per se*, has very little direct bearing on the incidence of the disease.

VIII. CARRIER RELATION TO THE EPIDEMIC.

It is to be remembered that Hong Kong is completely isolated and absolutely without expert advice; that in war time it took over two months for a mail to reach England; that works of reference are few in number and that the existence of the Medical Research Association brochure on cerebro-spinal fever was unknown in the colony until the arrival of Lieut. P. K. Olitsky, the Rockefeller Expert, on May 5th, 1918.

During the course of the epidemic therefore, the colony had to rely on its own resources.

At the request of the Hong Kong Government, the Rockefeller Institute very kindly lent the services of Lieut. P. K. Olitsky, for three months, to advise more especially on the preparation of serum and vaccine. This expert, however, did not arrive until May, when the epidemic was on the decline.

As a result of his bacteriological investigations in Hong Kong, he found that 95 per cent. of the 59 patients he investigated were infected with the Parameningococci of Dopter or Type 1 of Gordon's classification.

Lieut. Olitsky, undertook a personal investigation into the carrier ratio of the prisoners in the Victoria Gaol, and he states his results as follows:

“In conclusion, the results of the swabbing of a number of the inmates of the Victoria Gaol show:

1. That a number (24·61 per cent. of 130 inmates) of carriers of organisms indistinguishable from meningococcus had been found.

2. That these carriers harbour practically all types of the meningococcus.

3. That 3 of the carriers harbour organisms indistinguishable from the type of those found in the epidemic. One of these inmates carries almost a pure culture of one of the types prevalent in the epidemic.

5. Finally, among 600 or more prisoners no case of cerebro-spinal fever developed.”

It was decided soon after recognition of the epidemic that routine carrier search among the contacts was a practical impossibility, for the following reasons:

1. Recognition of the epidemic did not occur until the early phase of the epidemic was passed.

2. The bacteriological staff and material were inadequate to cope with the large numbers involved.

3. Great difficulty was foreseen in compelling, or persuading the Chinese to permit any such routine search.

4. Difficulties which would arise in dealing with the carriers when found.

To quote Dr Arkwright¹, “The conditions which made a search for carriers desirable was a possibility of their isolation during the early stages of an epidemic.” No such possibility existed in Hong Kong, and no attempt at a routine carrier search was carried out. It was arranged, however, to make a routine search for carriers in contacts of European cases, and this was done in the four European cases notified.

It was felt that something would have to be done to try and reduce the possibility of large numbers of carriers among the contacts. As no means existed of separating carriers from non-carriers, it was determined to act upon the assumption that all the contacts in the sleeping quarters on the same floor and using the same kitchen utensils, would be considered to be carriers and a possible source of infection.

The possibility of establishing steam inhalation chambers for the treatment of all contacts was considered, but in view of the difficulty of persuading the Chinese to go to any such place, and the necessity for immediately instituting some form of treatment, a small cheap portable atomiser, easily handled, which could be made locally, was designed by my husband at my request, to enable each sanitary inspector to carry out treatment of contacts in any infected house. Within a fortnight from the onset of the epidemic the first atomiser was in the hands of an inspector, and a few days later an atomiser of the

¹ Report of Proceedings of Epidemiological Section of the Royal Society of Medicine, *B.M.J.*, v. 3 15.

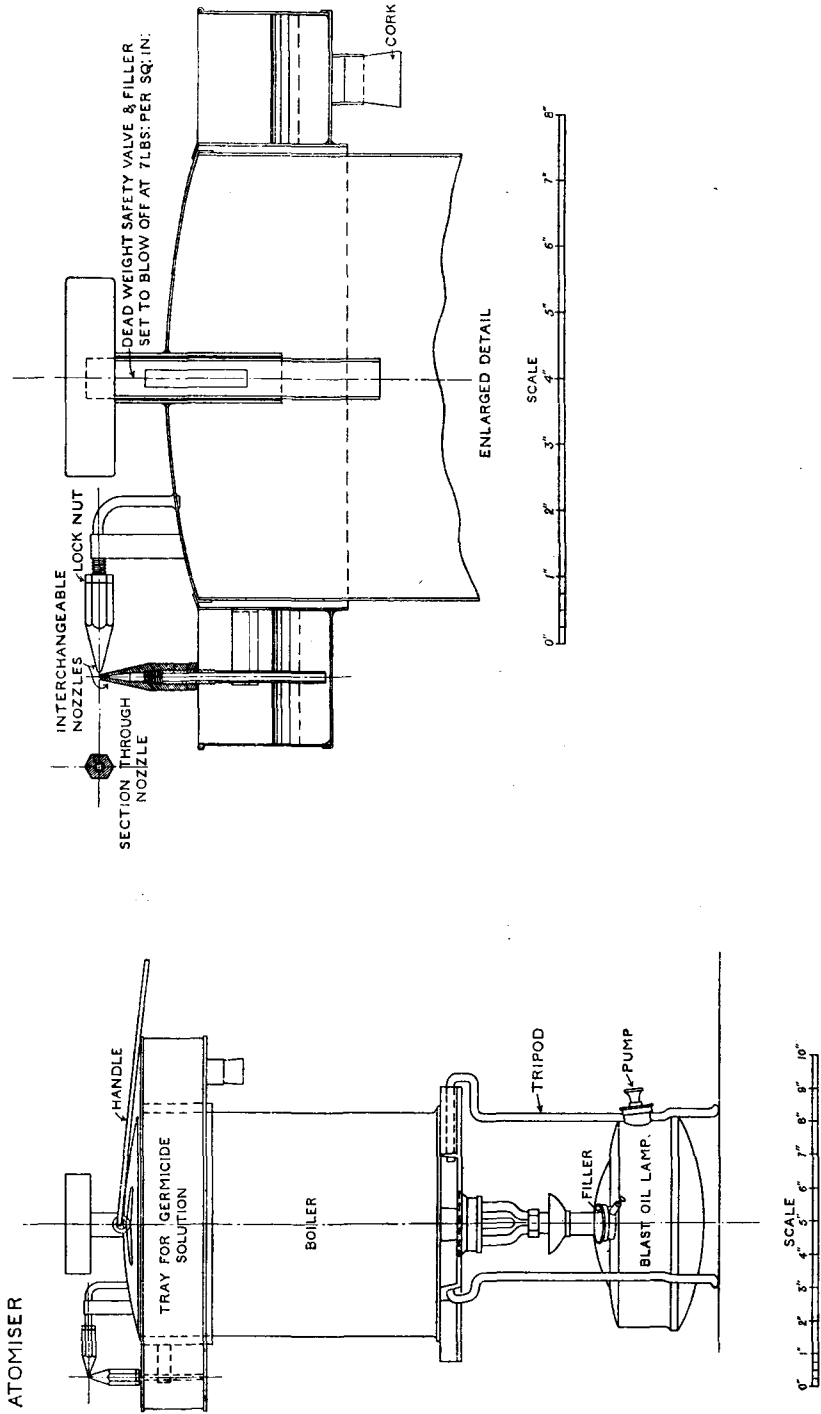


Fig. 1. Detailed scale drawing of construction of portable atomiser, designed by C. H. Gale for use in the Hong Kong epidemic.

improved design, as illustrated (see Fig. 1, p. 313), was in the possession of each of the 13 district sanitary inspectors.

As no chloramine-T could be obtained in the colony, it was a matter of necessity to use zinc sulphate in the atomisers. Zinc sulphate could be procured locally in large quantities, and had the additional virtue of being less unpleasant and irritating in use, a matter of some moment when it is remembered that the Chinese contacts had to be persuaded to take the treatment.

A rough-and-ready sort of inhalation chamber was devised in each house by setting the atomiser and its primus stove on a table inside the infected or other cubicle, and roofing in the cubicle with one of the Sanitary Board's canvas sheets. The average size of a cubicle is 8 ft. by 7 ft. by 6 ft., and an inspector, after a little experience, was able to manage the atomiser so as to ensure that one litre of 1 per cent. zinc sulphate solution was atomised in about 20 minutes, thus approaching as nearly as was possible to the instructions given for the use of Gordon and Flack's Falmouth Atomiser.

The family of the patient was treated first, and then all the remaining inhabitants of the room. As this had to be done during the day, it did not touch those who worked at any distance from their houses. Those who worked near were often fetched by their friends.

The inspectors called at each infected house daily for five days and treated each member of the household for five to ten minutes in the steam cubicle. The inspectors were instructed to pass each contact in turn in front of the atomiser and see that each one inhaled energetically while the steam played on the face. Some of the inspectors were more successful at this work than others and aroused so much interest in the Chinese that the inmates of the other floors in the infected tenement asked that they might also receive treatment.

In addition to this, a bottle containing the patent disinfectant Bacilli-Kil solution was left at each infected house and the inmates instructed how to gargle and wash out the naso-pharynx. This disinfectant is an American patent production supposed to be equivalent to freshly prepared eusol solution electrolysed and rendered stable. It could be obtained at once in considerable quantity at a fairly cheap price and, being pleasant and non-irritating to use, was the most suitable preparation for the purpose which could be obtained locally.

Whenever it became known that atomisers were being used for treatment of contacts an insistent demand was made by the public that atomisers should be installed at various centres in the colony for general use.

The majority of the schools were closed from the time of onset of the epidemic till February 27th for the China New Year holidays. It was asked by the Sanitary Board that when re-opened, each of the large schools should be provided with an atomiser, and that the pupils should all undergo the treatment. This was done on the understanding that each school would be capable of undertaking the entire charge of the atomiser. This was entered into most enthusiastically by the schools, and only one accident occurred, in

which one child was scalded, owing to the bursting of the atomiser, as a result of the tying down of the safety valve by the responsible person.

It is impossible to judge whether this had any bearing on the course of the epidemic, but the fact remains that after the schools re-opened, only three cases of cerebro-spinal fever were reported among some 6000 scholars.

Public opinion in the colony became somewhat divided on the value of the atomisers for general use, but there can be no doubt they served the useful purpose of a panacea for the panic stricken. Owing to the widespread fear of infection from the unknown carrier, the Europeans and better class Chinese eagerly sought medical advice as to prophylaxis. The chemists did a roaring trade and pounds of nasal ointment and gargles were sold daily. Some of the local medical profession thought that the use of the atomisers encouraged throat irritation, and others that it cured the colds which were so prevalent during the entire winter.

Much of the irritation said to follow the treatment was, no doubt, due to over-indulgence; some of the people being atomised two to three times daily for several weeks. For a time, at any rate, a section of the colony went atomiser mad.

Atomisers copied from the Sanitary Board pattern (see Fig. 1), were made privately by different firms and sold to the public, so that it may be taken for granted that a certain proportion of the public were most thoroughly and constantly atomised. Atomisers were in use at the Gaol, Police Court, and General Hospital for the use of the Staff.

During my voyage from Hong Kong to Canada in July, 1918, every person on board ship was obliged by Japanese Port regulations to spend five minutes daily in a zinc sulphate steam inhalation chamber. As the shade temperature was about 90° F. the heat of the chamber was most distressing, in spite of the steam used being drawn from the ship's steam pipes, and there were many complaints of faintness and headache. I found by experiment that it was possible, by sitting below the level of the steam nozzle, to escape these unpleasant sensations and, during the time spent daily in the steam chamber, I did not ever experience the taste of the zinc sulphate.

In Hong Kong, if the nozzle of the atomiser was correctly adjusted and inhalation took place while the steam was playing on the face, the metallic taste of zinc sulphate soon appeared and remained for some time afterwards.

As treating by steam atomised drugs is the object of treatment in the steam chamber, it is difficult to see what advantage the inhalation steam chamber possesses over the more simple method of inhalation from the steam atomisers.

It would appear that if there is any value in the inhalation of steam atomised drugs, the simple form of steam atomiser should prove as efficacious as the steam chamber. It has the additional value of being cheap, portable and easily handled by one man. It can be used on a coal or oil stove, gas, or electric heater, and can be manipulated by an unskilled operator.

Early in the epidemic the question of what was to be done with the carriers

in Hong Kong when they were discovered came up for much fruitless discussion, and His Excellency The Governor gave it as his opinion that Chinese carriers and cases could not be prevented from leaving the colony and that legal action in the matter was out of the question. As no routine carrier search was conducted and the number of known carriers bore no proportion to the number of cases, the question never became a pressing issue.

It was recommended by me at a special meeting of the local branch of the British Medical Association, called to discuss the epidemic early in March, 1918, that if the local medical profession would recommend their fearful patients, more especially delicate women and children, to wear some form of mask or veil to act as a physical screen against droplet infection when passing through thickly populated Chinese districts, that this might prepare the minds of the public for a possible measure of protection against carriers. If known carriers became numerous and isolation and consequent interference with the business life of the community impracticable, it might be possible to enforce the wearing by the carrier of some form of physical screen which would prevent him acting as a source of infection, and enable him to carry on his usual vocation without endangering the public safety and to the great saving of the public money.

The manager of one of the business offices in Hong Kong, visited daily by hundreds of Chinese coolies, asked if in addition to the atomisers anything else could be done to safeguard the office staff, who were very alarmed at the prospect of possible carrier infection. It was suggested that a strip of transparent, closely woven muslin, 3 ft. high, should be stretched from end to end of the counter, to act as a screen between those on either side of the counter. This was erected, and the muslin dipped in disinfectant and washed daily and the fears of the staff were at once allayed.

The public panic was a most noticeable feature of the epidemic in Hong Kong. This was due almost entirely to fear of the unknown healthy carrier, and the knowledge that no steps were taken to ascertain the numbers, or identity of such carriers.

It would appear from the experience gained in Hong Kong that the recognition, and isolations of carriers whilst of great scientific interest played no part in the checking of the course of the epidemic wave.

It, moreover, became evident that any isolation of contacts and healthy carriers when found would be a practical impossibility owing to the large numbers involved and the financial difficulties even if the legal difficulties could be overcome and compulsion applied.

It remains then to be considered what steps, if any, should be taken in any future epidemic of considerable dimensions to deal with contacts and carriers. One question that arises is whether it is worth while, even, if practicable, to try to isolate contact carriers seeing that during an epidemic a large proportion of the general public have also been found to be carriers.

It is impossible to investigate the naso-pharynx of an entire population, and anything less would only be half measures.

It would seem then that the problem must be attacked from another direction, and that in the present position of our knowledge all that can be done is to render the carrier as harmless as possible. If coughing, sneezing and spraying from the mouth is the recognised mode by which infection spreads then it should be a simple matter to devise some form of protection against this infection.

A screen of transparent celluloid which is absolutely impervious to droplet spraying would meet the case, and if the milliner and hatter were consulted, a hat and screen in one, or a screen to fit the fashionable hat of the moment could be designed which would be efficacious and inoffensive. The screen would require to be a reasonable distance from the face to allow of the use of a handkerchief, and should extend from the hat brim to below the chin level in order to completely enclose the face. The contacts might be required to wear this screen until proved to be non-carriers, or failing this, for a given length of time, and the general public advised to protect themselves against possible infection by wearing it. If the epidemic were of serious dimensions the wearing of a screen might be enforced. In the case of a native population such as exists in Hong Kong this would be impracticable but employers could insist on employees wearing a screen during business hours and if Europeans wore a screen as a preventitive measure the better class Chinese would soon follow suit and so a large section of the populace might be protected.

It would be at all events a step in the right direction, and once prejudice were overcome it would only be a question of time before the public would voluntarily use it during the course of an epidemic such as influenza or diphtheria, or any other disease suspected to be conveyed by droplet infection.

IX. SUMMARY OF CONCLUSIONS.

1. That there is reason to believe that sporadic cases of cerebro-spinal fever occurred in Hong Kong previous to the outbreak of the epidemic in 1918.
2. That the epidemic followed a widespread infection of influenza colds.
3. That the mortality out of a total of 1040 cases was 85.48 per cent.
4. That the most susceptible age was found to be the age period under five years.

The younger the individual, the greater the susceptibility, with the added proviso that the extremes of life suffered most.

5. That once the epidemic was established, a drop in the temperature, steadily maintained, accompanied by an increase in the saturation of the air as regards moisture, associated with a lack of sunshine, was found to be followed after a lag of a few days, by a rise in the number of cases. This lag showed a tendency to increase as the epidemic progressed, from three to four days at the beginning to six to seven days at the end of the epidemic.

6. That the number of cases in any given area varied directly with the overcrowding in that area, and this bears out the contention that overcrowding

is one of the most important features in the epidemiology of cerebro-spinal fever.

7. That the housing conditions in Hong Kong are such as to necessitate immediate action on the part of the Government, to safeguard the public health of the colony.

8. That new entries to Hong Kong formed a large proportion of the cases, and that this appears to be an important factor in the epidemiology of the disease.

9. That the poorest, most hard worked and badly housed portion of the community suffered most in the epidemic.

10. That the recognition and isolation of carriers is impracticable in an epidemic of any considerable dimensions.

11. That in the present condition of the knowledge of the means by which infection is spread, the wearing of a screen composed of some impervious material such as celluloid would seem to afford complete protection to the wearer against droplet infection.

12. That known carriers should be compelled to wear this screen until such time as they are proved free from the meningococcus. Thus protected, the carrier could pursue his usual avocation and the community be safeguarded from infection at a minimum of expense.